1 467 969

PATENT SPECIFICATION

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(19)

(54) INTERNAL COMBUSTION ENGINE AND OPERATING CYCLE

(71) I, HAAKON HENRIK KRISTIANSEN, a Canadian citizen, of, 484, Bedson Street, Winnipeg, Manitoba, Canada, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to new and useful improvements in internal combustion engines. Conventionally, such engines whether they are of the reciprocating piston type or the rotary type, utilize the Otto cycle or the Diesel cycle or the Dual Combustion cycle.

According to the present invention an internal combustion engine which includes fuel and air inlet means and exhaust means comprises in combination a hollow cylindrical stator, closed at each end thereby defining a cylindrical chamber therein, a cylindrical rotor within the stator journalled for rotation there within, means to journal the rotor for rotation within the stator, a cam ring for the rotor, a plurality of cylindrical bores formed in the rotor with the axes thereof parallel to the axis of the rotor, and spaced around the axis of the rotor, a piston reciprocal in each of the bores, a cylinder head common to the plurality of the bores, and means operatively connecting the pistons to the profile of the cam ring whereby rotation of the rotors carries the said means connecting the pistons around the cam ring profile thereby controlling the reciprocal motion of the pistons within the bores, and a combustion chamber in the cylinder head operatively connected to the fuel and air inlet means, which chamber in use is brought into communication with each cylinder in the rotor in succession.

Preferably the engine includes a cylinder head at each end of the stator, a pair of cylindrical rotors within the stator journalled for rotation within the cylindrical chamber thereof, one adjacent each end of the stator, means mounting the rotors on a common axis within the stator for rotation therein, and a pair of cam rings secured intermediate the ends of said cylindrical chamber, said means operatively connecting the pistons of one of the rotors with one of the cam rings, and similar means operatively connecting the pistons of the other of the rotors with the other of the cam rings.

With the engine of the present invention the expansion ratio or stroke can be made greater than the compression ratio or stroke thereby converting some of the energy normally expelled and wasted in the exhaust gases, to useful work or horsepower.

The invention will now be described by way of example with reference to the accompanying drawings in which:

Figure 1 is an isometric partially schematic view of one embodiment of the engine;

Figure 2 is an end view of Figure 1 with one cylinder head removed;

Figure 3 is an enlarged schematic section along the line 3—3 of Figure 2;

Figure 4 is a fragmentary plan view substantially along the line 4—4 of Figure 3;

Figure 5 is a fragmentary view showing an alternative construction of the connection of the piston to the cam ring;

Figure 6 is a schematic view of the cycle of operation of the engine utilizing the improved cycle;

Figure 7 is an isometric view of one of the connecting rods showing two alternative connections of the rod to the cam ring as illustrated in Figures 3 and 5;

Figure 8 is an operating diagram of the improved cycle using a carburetor;

Figure 9 is a view similar to Figure 8, but showing the cycle used with a diesel operation; and

Figure 10 is an isometric, partially sectioned view of an alternative embodiment of the invention.

In the drawings like characters of reference indicate corresponding parts in the different figures.

Although the drawings illustrate a novel engine utilizing the new cycle of operation in which the expansion stroke is longer than the compression stroke, nevertheless it will be appreciated that the novel engine can be constructed to operate on a conventional cycle in which the lengths of stroke are equal under

which circumstances only one rotor may be utilized. Furthermore, when used with a conventional cycle of operation, the engine is readily adapted for use with either a two or four-stroke cycle.

Also to be appreciated is the fact that the novel cycle described herein can readily be used with other conventional rotary type engines whether these engines are rotary piston type or not.

With a conventional opposing piston engine, a cam-type crank shaft can be utilized so that the expansion stroke is longer than the compression stroke and by modifying the lobe of a rotary engine such as the Wankel, a similar effect can be obtained.

The novel cycle described herein may be defined as a cycle based on the Otto, Diesel or Dual Combustion cycle, but having an expansion ratio greater than the compression ratio, said expansion ratio being less than that required to expand the gases to atmospheric pressure. This cycle is achieved within one cylinder or chamber and is a geometrical and volumetrical ratio in which a motion of a chamber, or cylinder and piston, produces a geometrical ratio which theoretically is the same as the volumetrical ratio. This eliminates dead motion as in the case of some engines which reduce the volumetrical compression ratio in comparison to the geometrical ratio by either early or late intake valve closing.

Proceeding therefore to describe the invention in detail, reference should first be made to Figures 8 and 9 which show pressure diagrams for the new cycle using a carburetor in the case of Figure 8 and a diesel cycle in the case of Figure 9.

The line between positions 1 and 2 illustrates the compression stroke, and between 2, 3 and 4, the conventional expansion stroke at the end of which the exhaust valve normally opens.

In the present cycle, the expansion stroke extends from position 2 through 3, 4 and to position 5 thus utilizing more of the power developed by the fuel than heretofore.

Approximately 30% more power can be utilized at all power settings thus increasing the efficiency of the engine whether using carburetor, diesel or dual combustion type cycles of operation.

Figures 1 to 7 show one embodiment of a novel engine which may utilize this cycle although of course, it will be appreciated that a conventional cycle can be used.

Proceeding to describe the engine in detail, reference to the accompanying drawings will show a substantially cylindrical stator collectively designated 10 which is provided with a cylindrical chamber formed therethrough.

Each end of this cylindrical chamber is closed by means of a cylinder head 12 secured by bolts 13 with a conventional type seal 14 being provided between the cylinder head 12 and the cylindrical stator 10.

A cylindrical rotor 15 is mounted for rotation within each end of the stator 10 and both rotors are secured to a common shaft 16 which in turn is supported within bearings 17 provided centrally of each cylinder head 12.

Each rotor 15 is provided with a plurality of piston bores 18 equidistantly spaced around the axis of the rotor as clearly illustrated in Figure 2 and a piston 19 is provided for each bore and is reciprocal therein, conventional piston rings 20 being provided as shown.

The rotors 15 are situated at each end of the stator as hereinbefore described, with the outer ends 21 in bearing contact with the cylinder heads and sealed by means of annular seals 22 which are shown schematically in Figure 3. However, these seals are preferably labyrinth type seals which are well known so that it is therefore not believed necessary to describe same further. However, optional radial seals 22A may be incorporated between each cylinder (see Figure 2).

Annularly formed fluid passages 23 may be provided in each of the rotors and connected to an external source for cooling purposes.

A pair of cam rings 24 are provided intermediate the ends of the stator 10 and are secured around the wall of the cylindrical chamber 11 by means of bolts 25 screw threadably engaging the cam rings 24 through elongated slots 26 in the wall of the stator and these cam rings 24 may be rotated within limits, for purposes hereinafter to be described, by any convenient means. In the present embodiment, such means includes gear teeth 27 formed around part of the outer periphery of the two cam rings 24 engageable by a gear 28 mounted upon a shaft 29 which in turn may be rotated through gear 30 from any convenient location so that rotation of shaft 29 will move the cam rings 24 annularly within limits.

Each cam ring is U-shaped when viewed in cross section and reference should be made to Figure 3. Each cam ring includes a cam base 31 with inner and outer walls 32, each wall 32 having an annular channel 33 as clearly shown in figure 3. This annular channel rises and falls axially through 360°, the profile of the channel being shown specifically in Figure 6 and this channel forms the profile of the two cam rings, one being a mirror image of the other as clearly illustrated in Figure 6.

Means are provided to connect the pistons 19 with the cam rings, said means taking the form of a connecting rod or link shown specifically in Figure 7.

The inner end 34 of the connecting rod means 35 is provided with a wrist pin 36 which pivotally connects the inner end to the

piston 19 through bosses provided (not illustrated) in the usual manner.

The lower end 37 of the link 35 is wider than the inner end 34 and is provided with rollers upon either side thereof.

Figure 3 shows one embodiment of these rollers in which a relatively large roller 38 is journalled for rotation upon a pin 39 extending from either end of the portion 37 and these relatively large rollers are in rolling contact with one wall 40 of the annular channel 33.

A smaller roller 41 is also journalled for rotation upon the end of pin 39 and is in contact with the other wall 42 forming the annular channel 33 so that these two rollers anchor the connecting rod means 35 within the profile of the cam ring defined by the annular channel 33.

Alternatively, a single relatively wide roller 43 can be journalled for rotation upon the end of pin 39 and engage within a modified channel shown in Figure 5.

In either embodiment, rotation of the rotor within the stator will cause the rollers on each piston to roll around the cam profile and the shape of this profile causes these pistons to reciprocate within the piston bores 18 in a clearly defined sequence.

If the profile of the cam ring is symmetrical then the length of the stroke of the pistons 19 will be the same, but if the profile is modified as illustrated in Figure 6, then the length of the stroke of the pistons while travelling around one portion of the cam profile will be different from the length of the stroke of the piston travelling around the remainder portion of the profile.

For example, by programming the profile, intake and compression strokes can be performed by each piston together with expansion and exhaust strokes through one rotation of the rotor (360°) and the shape of the profile will cause the intake and compression strokes to be shorter than the expansion and exhaust strokes.

By providing two rotors with two sets of pistons and two cam rings, one being a mirror image of the other, a balance is achieved and vibration is reduced. Two such systems are shown in Figure 6 schematically.

A relatively small arcuately curved firing chamber 44 is formed in each of the cylinder heads and at this location either a spark plug 45 or a fuel injection nozzle 46 is provided depending upon the system being used.

An intake port 47 extends through the cylinder head together with an exhaust port 48 and these are shown schematically in Figure 2 and Figure 6.

Figure 6 shows one cycle of two opposed pistons specifically designated 19A in Figure 6. The cycle extends through 360° or one revolution of the two rotors 15.

At the first position (0°3 the pistons are at approximately top dead center and are moving inwardly as they pass the intake conduit 47. Assuming an engine using a carburetor, the pistons will draw in a gasoline/air mixture during the intake stroke through approximately 90°.

At the first position (0°) the pistons are at intake ports 47, they commence moving outwardly and compress the gases between the piston head and the cylinder head for a stroke having the same length as the intake stroke. As they reach one end of the small combustion chamber 44, spark plug 45 is fired thus igniting the mixture which causes an expansion stroke and causes the pistons to move inwardly through approximately a further 90°. However, due to the shape of the cam profiles, this expansion stroke is longer than the compression stroke by an amount indicated in Figure 6 by reference character 49 and as the pistons approach the innermost position at approximately 270°, the exhaust port 48 is reached and the spent gases are expelled through the exhaust port during the exhaust stroke which is the same length as the expansion stroke. Due to the longer expansion and exhaust strokes, these strokes will exceed 90° rotary travel and the intake and compression strokes will be less than 90° rotary travel.

Each succeeding piston follows the same path so that there is a relatively continuous firing and the combustion chamber 44 spans or overlaps two or more cylinders. This serves two purposes. First, to stratify the charge with a carburation type engine and secondly, to assist in continuous burning with the injection type engine. Both systems serve to assist in burning a lean mixture and thereby assist further in meeting present day emission standards.

The stratified charge is achieved by having the mixture compressed in the cylinder and also in the combustion chamber 44 in its lean state. Since the combustion chamber 44 contains less oxygen due to being purged by hot combusted gases from the previous cylinder, the mixture in the combustion chamber can be considered richer than in the main cylinder. The mixture in the combustion chamber 44 is then ignited by the hot gases from the neighbouring cylinder in its rich state and then this initial combustion is purged into the main cylinder to ignite the leaner mixture. Alternatively it is also possible to combine the two systems by having a small amount of fuel injected into the mini combustion chamber while the lean mixture in the main cylinders are provided by a carburetor. A stratified charge may be defined as a combustion system which has a richer mixture ignited initially and this ignition travels into a leaner zone.

The thermal efficiency is increased considerably with the novel cycle and the thermal efficiency of conventional cycles is expressed in the formulae:

$$e = 1 - \frac{T4 - T1}{T3 - T2} \text{ for Otto and Brayton cycle}$$

$$e = 1 - \frac{1}{k}\,\frac{(T4 - T1)}{(T3 - T2)} \text{ for the Diesel cycle}$$

$$e = 1 - \frac{T4 - T1}{(T2' - T2) \neq \frac{1}{k}(T3 - T2')} \text{ for the Dual Combustion Cycle.}$$

In the above formulae,

T1 = Temperature of the intake air

T3 = Temperature of the combusted mixture

T4 = Temperature of the Exhaust gases

T5 = Temperature of the Exhaust gases in the new cycle.

It is believed that the exhaust temperature with improved cycle is approximately 1,000°R (Rankin) lower than the Otto or Diesel cycle so that by substituting this new figure (T5) for T4 in the above formulae, the thermal efficiency in the new cycle is approximately 30% higher of the original thermal efficiency.

As mentioned previously, Figure 6 shows a new cycle in which the expansion and exhaust strokes are considerably longer than the intake and compression strokes, but of course it will be appreciated that by suitably shaping the cam profiles, the strokes can be made the same length.

The aforementioned gear 28 may be used to rotate the cams slightly with reference to the position of the combustion chambers 44 thus varying the timing of the ignition of fuel injection.

By the same token, by changing the relationship between the two cams axially, as by inserting or withdrawing shims 50 between the two cams, the compression ratio may be varied within limits. This also may be done while the engine is running by means of simple linkage and movable shims (not illustrated).

The preceding description covers the embodiment shown in Figures 1 through 5 and Figure 7, in which the cam rings 24 are situated centrally of the stator 10 and the cylinder heads 12 are situated at each end thereof.

However, it will of course be appreciated that the positions of these parts may be reversed with the cam rings situated adjacent the ends of the stator and a common cylinder head being situated intermediate the ends of the stator and such a design is shown in Figure 10. Where applicable, similar reference characters have been given, but with a prime distinguishing them from the reference characters of the other views.

The cylindrical stator 10′ is provided with a cylindrical chamber 11′ formed thereby.

End plates 51 are secured to each end of this cylindrical stator by means of bolts 13′ and bearing assemblies 52 are provided centrally within the end plates 51 to support for rotation, a common shaft 16′.

A cylindrical rotor collectively designated 53 is secured to shaft 16′ as by splines or the like (not illustrated), there being a pair of rotors provided in this embodiment one upon each side of a common cylinder head 54. This cylinder head is secured within the stator 10′ centrally thereof and spans the cylindrical chamber 11′ as clearly illustrated. It is provided with a spark plug such as indicated by reference character 55 although, if desired, fuel injection means may be provided at this point. The spark plug or fuel injection means communicates with a small combustion chamber 56 formed through the cylinder head 54 so that it communicates with the rotor 53 on either side of the cylinder head.

Exhaust means 56 communicate with a common exhaust port 57 within the cylinder head 54 and an air intake or air/fuel intake is provided on the opposite side of the cylinder head (not illustrated) similar to the intake 47 of the previous embodiment.

From the foregoing it will be appreciated that the combustion chamber 56 is common to both rotors 53, together with the exhaust and intake port means.

Each rotor 53 is mounted upon shaft 16′ as hereinbefore described and includes a centrally located support plate 58.

Cylinder bores 59 are formed annularly within a block 60 extending upon one side of plate 58 and being secured thereto and these bores are parallel to the axis of the shaft 16′.

A support cylinder 60 is secured to the other side of plate 58 one each in alignment with the bores 59 and these support cylinders are provided with longitudinally extending channels 61 upon each side thereof within which is supported for reciprocation, a bifurcated end 62 of a connecting rod 63 which extends from the underside of each piston 64 which in turn reciprocates in each of the

bores 59. The rod 63 and the piston 64 are preferably formed from one piece and the support cylinders 60 are bifurcated as illustrated at 65 for reasons which will hereinafter be described.

Alternatively, the cylinders and support cylinders 60 may be formed of hollow cylindrical shells clamped between upper and lower plates, but as this is considered to be an obvious alternative, it is not believed necessary to describe same further.

However, it should be observed that the claims are intended to cover both structures.

A cam ring 66 is secured within each end of the stator 10′ adjacent the end plates 51 and this cam ring includes the support base portion 67 and a T-shaped portion collectively designated 68. This T-shaped portion includes a web 69 and a flange 70 extending upon each side of the edge of the web as clearly shown in Figure 10 and the bifurcated formation of the support cylinders 60 permits rotation of the rotor around the cam ring with a portion of the web and the flange 70 being situated within the bifurcated slots 65.

Means are provided to connect the ends 62 of the connecting rod to the cam rings and in this connection these ends 62 are bifurcated to form two side portions 71 between which is situated a first roller means 72 supported for rotation upon a pin 73 extending between the bifurcated portions 71.

This roller rides upon the outer surface 74 of the flanges 70 as clearly shown.

A pair of smaller rollers 75 are journalled for rotation upon pins 76, one disposed upon each side of web 69, but being spaced from the main or first roller 72 and each of these small rollers 75 engages the inner surface of the flanges 70, one upon each side of the web 69 thus ensuring that the roller 72 follows the contour of the T-shaped portion of the cam in a manner similar to that described for the previous embodiment.

The operation of the embodiment of Figure 2 is similar with the exception that the common combustion chamber 56 communicates with the cylinders of each rotor, it being understood that a pair of pistons 64 are in opposition at the time of firing so that the expansion stroke reacts upon both pistons which are at the combustion chamber location.

By the same token, the exhaust and intake ports communicate with the cylinders of each rotor as they pass thereby.

Once again the cam rings 66 may be rotated slightly to alter the timing and the position of the cam rings relative to the end plates 51 may be varied by shims (not illustrated) or other similar means so that the compression ratio may be varied within limits.

Although both embodiments illustrate and describe opposed rotor assemblies within a common stator, nevertheless it will be appreciated that a single rotor can be used with a single cam ring and single cylinder head although, under these circumstances, it is desirable that the length of all strokes are equal in order to reduce vibration.

WHAT I CLAIM IS:—

1. An internal combustion engine which includes fuel and air inlet means and exhaust means; comprising in combination a hollow cylindrical stator, closed at each end thereby defining a cylindrical chamber therein, a cylindrical rotor within the stator journalled for rotation therewithin, means to journal the rotor for rotation within the stator, a cam ring for the rotor, a plurality of cylindrical bores formed in the rotor with the axes thereof parallel to the axis of the rotor, and spaced around the axis of the rotor, a piston reciprocal in each of the bores, a cylinder head common to the plurality of bores, and means operatively connecting the pistons to the profile of the cam ring whereby rotation of the rotors carries the said means connecting the pistons around the cam ring profile thereby controlling the reciprocal motion of the pistons within the bores, and a combustion chamber in the cylinder head operatively connected to the fuel and air inlet means, which chamber in use is brought into communication with each cylinder in the rotor in succession.

2. The engine according to Claim 1 which includes a cylinder head at each end of the stator, a pair of cylindrical rotors within the stator journalled for rotation within the cylindrical chamber thereof, one adjacent each end of the stator, means mounting the rotors on a common axis within the stator for rotation therein, and a pair of cam rings secured intermediate the ends of said cylindrical chamber, said means operatively connecting the pistons of one of the rotors with one of the cam rings, and similar means operatively connecting the pistons of the other of the rotors with the other of the cam rings.

3. The engine according to Claim 2 in which the stator includes an end plate at each end thereof and a common cylinder head situated intermediate the ends thereof, a cam ring situated adjacent each end of the stator, the combustion chamber in the cylinder head being operatively connected to opposing pairs of cylinders in the rotors as said cylinders pass thereby.

4. The engine according to Claims 1, 2 or 3 in which the engagement of said means connecting said pistons with the profile of the cam rings provides, in 360° of rotation of the rotor, an intake stroke, a compression stroke, an expansion stroke, and an exhaust stroke for each of the pistons.

5. The engine according to Claim 2 which includes means to vary the compression ratio of the pistons within the cylinders, within limits, said last mentioned means including

varying the axial distance between the cam rings thereby moving said cam rings towards or away from said cylinder heads of said stator.

6. The engine according to any of the preceding claims in which said means connecting said pistons to the profile of the cam ring includes a connecting member connected by one end to the piston, and said means also includes further means connecting the other end of the connecting member to the cam ring profile, the further means including the cam ring which has an annular base portion with spaced inner and outer walls extending at right angles from the base portion, annular channels formed on the opposed surfaces of the inner and outer walls, the side walls of the channels comprising bearing surfaces, and said further means also includes first roller means on the connecting member engaging one of the side walls, second roller means rolling in said annular channel and engaging the other of the side walls whereby said first and second roller means retains said other end of said connecting rod means in rolling engagement within the channels, the channels forming the cam ring profile.

7. The engine according to any of the claims 1 through 5 in which said means connecting the pistons to the profile of the cam ring includes a connecting rod connected by one end to the piston, and said means also includes further means connecting the other end of the connecting rod to the cam ring profile, the further means comprising a web portion on the cam ring and a flange extending at right angles on each side of one edge of said web portion, a bifurcated end formed on said other end of the connecting rod, and said further means also includes first roller means journalled within the bifurcated end and engaging the outer surface of said flanges, a pair of second roller means journalled within the bifurcated end of the connecting rod spaced from said first roller means and engaging the inner surface of the flanges, one upon each side of the web portion.

8. The engine according to any of the preceding claims in which the cam profile is such that the expansion and exhaust strokes of each of the pistons are longer than the intake and compression strokes thereof.

9. The engine according to Claim 3 which includes means to control the timing, relative to said end plates, of the strokes of the pistons within limits.

10. The engine according to any of Claims 2, 3, 4, 5, 6 or 7 including means to rotate the cam rings within limits, relative to the stator thereby advancing or retarding top dead center of the pistons.

11. An internal combustion engine substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

WITHERS & ROGERS,
Chartered Patent Agents
148—150 Holborn,
London, EC1N 2NT,
Agents for the Applicant.

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7 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

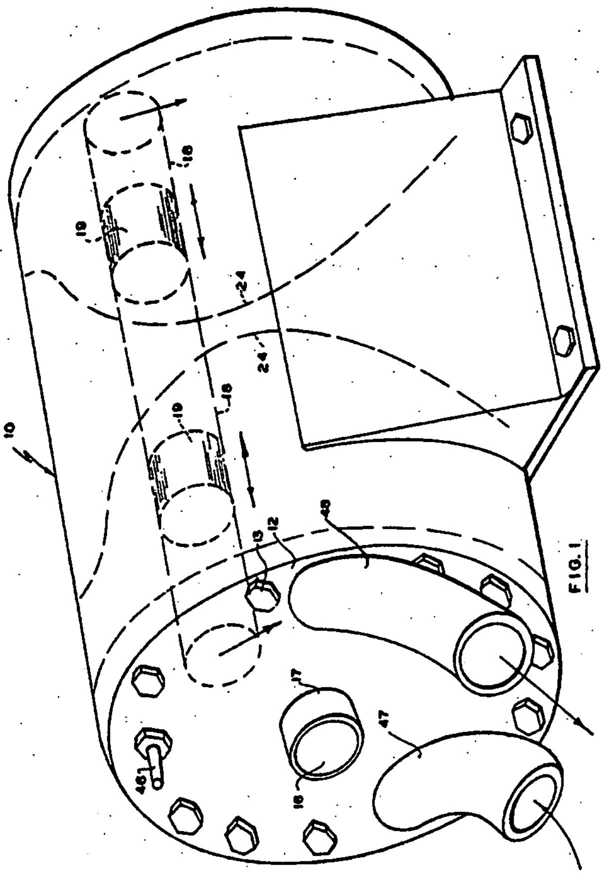

FIG. 1

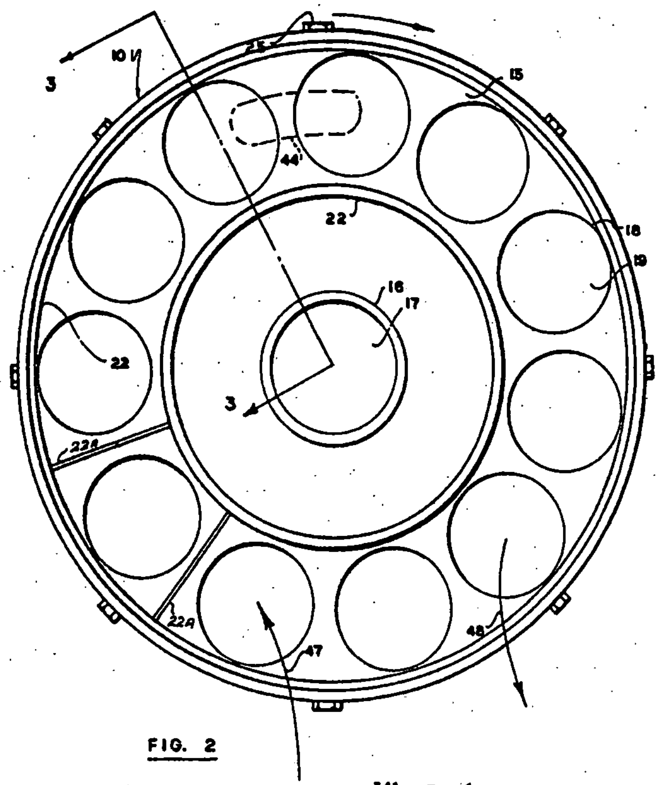

FIG. 2

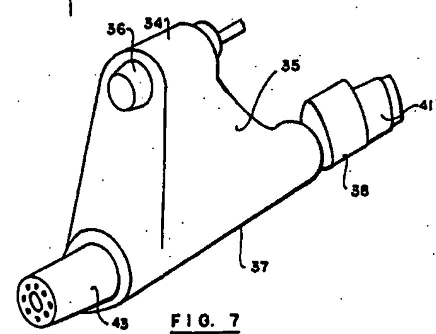

FIG. 7

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Sheet 3

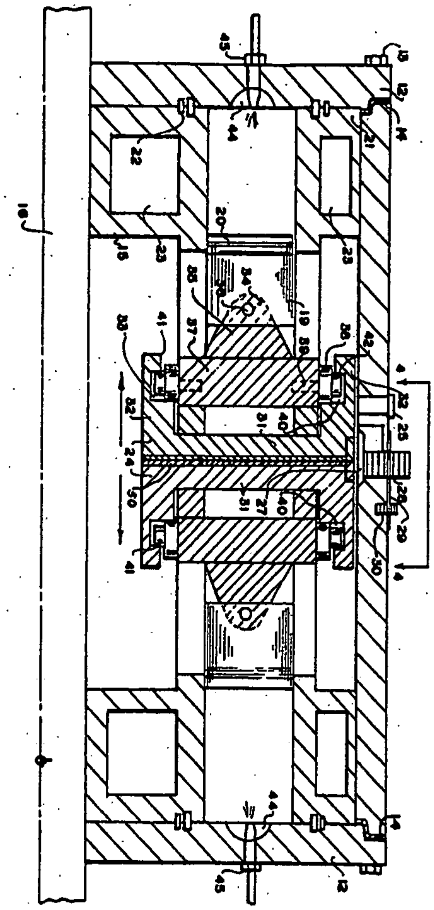


FIG. 3

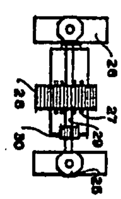


FIG. 4

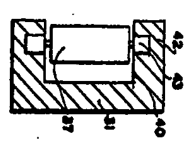
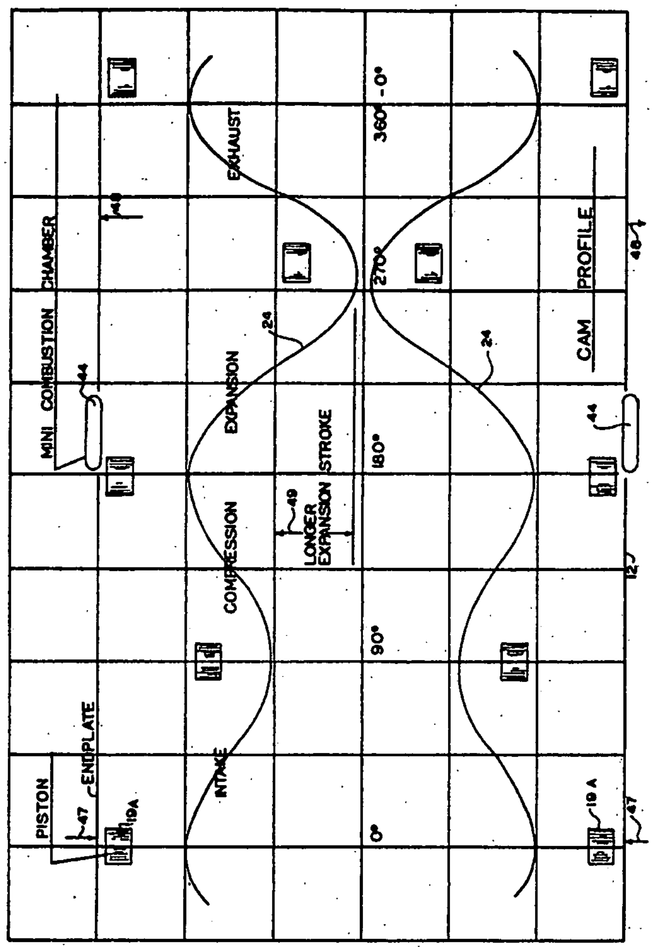


FIG. 5

FIG. 6


MINI COMBUSTION CHAMBER
48
44
EXHAUST
360°-0°
270°
24
EXPANSION
180°
STROKE
LONGER EXPANSION
49
COMPRESSION
90°
INTAKE
0°
PISTON
ENDPLATE
47
19A
CAM PROFILE
12

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Sheet 5

FIG. 8

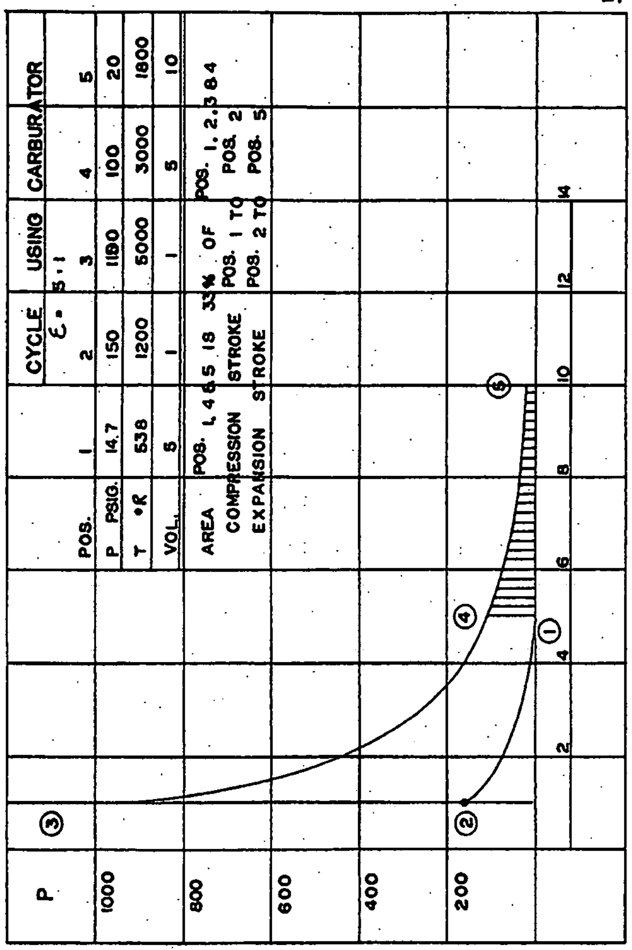
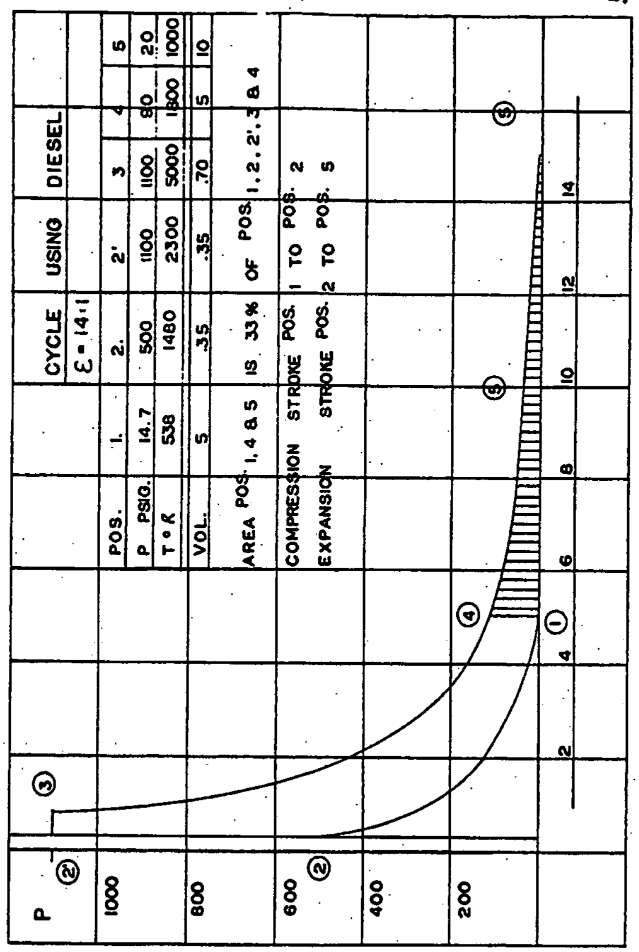


FIG. 9


CYCLE USING DIESEL
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P PSIG. 14.7 500 1100 1100 90 20
T°R 538 1480 2300 5000 1800 1000
VOL. 5 .35 .35 .70 5 10
AREA POS. 1, 4 & 5 IS 33% OF POS. 1, 2, 2', 3 & 4
COMPRESSION STROKE POS. 1 TO POS. 2
EXPANSION STROKE POS. 2 TO POS. 5
P
1000
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Sheet 7

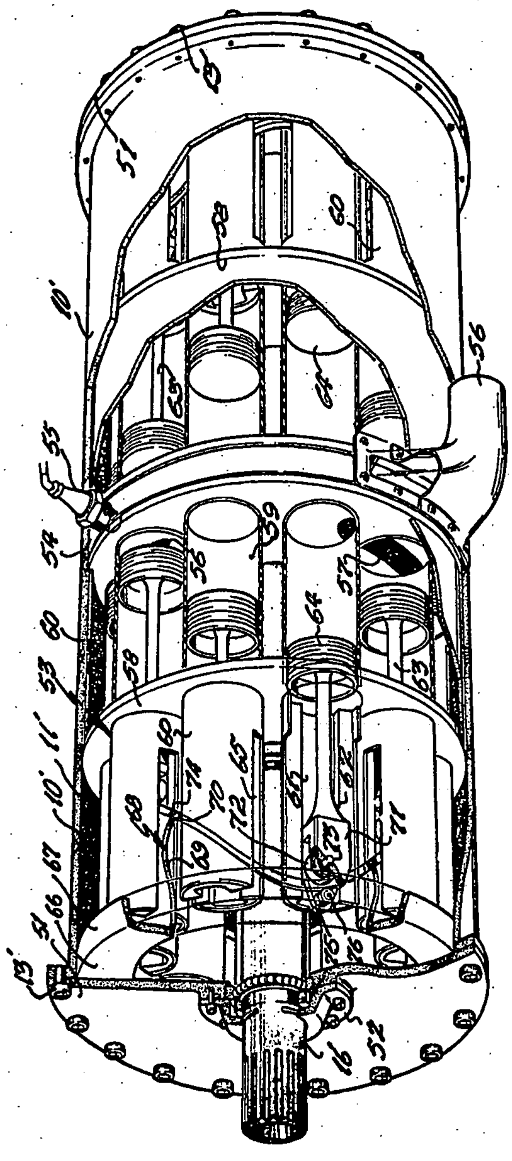

FIG 10